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PHYSICS.—*Note on a general method for determining properties of matter.*[1] MAYO D. HERSEY, Massachusetts Institute of Technology.

Physical properties of substances, for example, thermal and electrical conductivity, density, viscosity, and surface tension, are usually determined by one or the other of the two following methods. (1) Absolute measurement, involving comparatively expensive apparatus and detailed mathematical analysis. (2) Relative measurement in terms of the properties of a standard sample. This method is comparatively simple and economical, but has almost always been restricted in the past to those few phenomena where the desired property is directly proportional to the observed action, or to some definite function of the observed action which can be written down in advance of the experiment. It is the object of the present paper to indicate a third category of experiments which should be available for determining properties of matter, much less restricted in character than those mentioned above; and to formulate a general method for interpreting the observations.

This third group of phenomena are characterized by the fact that the observed action will not be directly proportional to the property in question, nor even uniquely determined by it, and it is quite immaterial if the details of the phenomenon are too irregular to be analyzed mathematically. The proposed method for interpreting such observations consists merely in applying the principle of dynamical similarity (or physical similarity) backwards. Instead of employing this principle to predict the course of a phenomenon, when the properties of matter involved are altered in a known manner, it is now proposed to turn it around, and deduce the relative magnitudes of the properties of matter involved in two successive experiments, by observing the phenomena in both cases.

This possibility must immediately suggest itself to anyone familiar with the principle of similarity or the theory of dimensions, and it

[1] Received January 24, 1922.

was in fact first brought to the writer's attention through a specific instance discussed by Dr. E. Buckingham[2] at the Philosophical Society of Washington in 1916 in connection with the subject of efflux viscosimeters.

When attempting to reverse the principle of dynamical similarity, it is in general impossible to predetermine the necessary conditions because the resulting forces or motions cannot be experimentally controlled or foreseen. It is an essential feature of the proposed demonstration to show that this can be done by securing fictitious similarity by graphical interpolation among two or more experimental trials which approximate, but do not exactly realize, the conditions for similarity. Before treating the problem symbolically, this feature will be illustrated by concrete examples.

Viscosity measurement.—The familiar equation for fluid resistance due to Lord Rayleigh may be written

$$R = \rho D^2 v^2 \, f\left(\frac{Dv\rho}{\mu}\right) \tag{1}$$

in which R denotes the resistant force, D some linear dimension of the body, and v its relative speed through the medium of density ρ and viscosity μ. The function f is the same for all geometrically similar bodies. This equation can be solved for the unknown viscosity μ and written

$$\mu = Dv\rho \, \psi\left(\frac{R}{\rho D^2 v^2}\right) \tag{2}$$

or, when D and ρ are constant,

$$\mu = v \, \phi\left(\frac{R}{v^2}\right) \tag{3}$$

Now, if the functions ψ or ϕ were known, either of these equations could be used as it stands for the determination of absolute viscosity from observations on the resistance and speed. But for the purpose of relative determinations, the form of the function need not be known, as will presently appear. For suppose that the apparatus, when supplied with a standard sample of viscosity μ_o, gives an observed resistance R_o at the speed v_o, while the sample under test gives some different resistance R at a speed v; then if

$$\frac{R}{v^2} = \frac{R_o}{v_o^2} \tag{4}$$

[2] THIS JOURNAL 6: 154–155. 1916.

the unknown function ϕ will be numerically the same in the two experiments, so that Equation 3 gives

$$\frac{\mu}{\mu_0} = \frac{v}{v_0} \tag{5}$$

If the condition for dynamical similarity expressed by Equation 4 above could be realized at the first trial, then a single experiment on the test sample would be sufficient. In practice two or more experiments should be made and the observed values of R plotted as ordinate against v^2 as abscissa. Draw a straight line from the origin through the point whose coördinates are R_0 and $v_0{}^2$. Suppose this line intersects the empirical curve for the test sample in some point P. Then the condition for dynamical similarity (Eq. 4) is exactly realized at the point P, although this is a fictitious point and not a real observation. Therefore, the abscissa v_1 of the point P satisfies Equation 5 and is to be substituted for v in that equation when using it as a working formula.

If the size of the body which is towed through a fluid, or the density of the fluid, are not constant, Equation 2 can be employed instead of Equation 3, and for this purpose Equation 2 may be rewritten

$$\mu = x\,\psi(y) \tag{6}$$

in which x denotes $Dv\rho$ while y stands for the dimensionless variable $R/\rho\ D^2v^2$. Using subscript zero hereafter to refer to the standard substance, Equation 6 gives for the standard viscosity

$$\mu_0 = x_0\psi(y_0) \tag{7}$$

Now plot experimental values of y/y_0 as ordinate, against x/x_0 as abscissa, and call x_1/x_0 the abscissa of the point where the empirical curve crosses the horizontal straight line $y/y_0 = 1$. Dividing (6) by (7) the final formula becomes

$$\frac{\mu}{\mu_0} = \frac{x_1}{x_0} \tag{8}$$

of which (5) above may be considered a special case.

Thermal conductivity.—Let it be required to determine relative thermal conductivity λ/λ_0 by successive observations of the temperature rise Δ on the sample under test and on a standard sample which is geometrically similar to it. When the steady state has been reached, the heat input H will be just equal to the heat carried off from the exterior of the sample by the convective action of some cooling agent such as a vigorously stirred water bath. If the specific heat of this

medium is denoted by S and its rate of flow in mass units per unit of time by M, then the temperature elevation will be given by an equation of the type

$$\Delta = F(\lambda, H, D, M, S) \tag{9}$$

in which D denotes some linear dimension of the sample. (This equation is only approximately complete; while serving well enough as it stands for the purpose of illustration, it can in practice be made more exact by introducing the additional variables ρ, μ and λ' to denote, respectively, the density, viscosity, and thermal conductivity of the cooling agent, which will have some influence on the rate of heat transfer, though not so much as the quantities M and S.) Equation 9 can be further developed by dimensional theory, and then solved for the conductivity λ, whereupon it goes over into the form

$$\lambda = \frac{H}{D\Delta}\phi\left(\frac{MS\Delta}{H}\right) \equiv x\phi(y). \tag{10}$$

In the second part of this equation x has been written for $H/D\Delta$ and y for $MS\Delta/H$. Plot observed values of y/y_o as ordinate against x/x_o as abscissa, and denote by x_1/x_o the abscissa of the point where similarity occurs; that is, the point where the empirical curve crosses the line $y/y_o = 1$. Referring therefore to Equation 10, the relative conductivity will evidently be given by the formula

$$\frac{\lambda}{\lambda_o} = \frac{x_1}{x_o} \tag{11}$$

In the more exact solution suggested above, the consideration of ρ will introduce an additional argument ρ^2HD^4/M^3 into Equation 10, while the recognition of μ will add an argument of the form $\mu D/M$, and so on if additional correction terms are included. In order to apply the routine reasoning above, which was based on Equation 10, these new arguments must now be held constant, which may or may not be experimentally practicable, although possible in principle if suitable facilities are provided. For example, to keep the argument ρ^2HD^4/M^3 constant, it is sufficient to increase the mass flow in proportion to the cube root of the heat input, whenever the latter is changed.

General formulation.—The procedure illustrated above may be outlined in more general terms as follows:

1. Develop the appropriate dimensionless equation for some chosen

phenomenon which exhibits the desired property of matter Q. This can be done by the Π-theorem method[3] and requires first of all a complete list of the physical quantities which would influence the phenomenon if they were to vary. Solve this equation for Q and let the result be written

$$Q = X\,\Psi(Y, Z, ..) \tag{12}$$

in which Q/X, Y, Z, ... are dimensionless variables, Ψ being an unknown function.

2. The experimental facilities must now be so arranged that all dimensionless variables other than Q/X and Y, for example Z (if any such appear), shall be kept constant. Under these conditions (12) reduces to

$$Q = X\,\psi(Y). \tag{13}$$

3. If any of the individual physical quantities entering the dimensional factor X or the dimensionless argument Y are known to be constant during the experiment, they can be left out, so that X and Y degenerate respectively into the dimensional factors x and y, and (13) takes on the more simple form

$$Q = x\,\phi(y). \tag{14}$$

Equation 14 could have been deduced at the start in place of (12) by utilizing Buckingham's recent method of suppressed dimensions.[4]

4. Take observations of the phenomenon in question when the apparatus is supplied with a standard sample, for which Q (whether numerically known or not) may be written Q_o. Denote the values of x and y which prevail during this experiment by x_o and y_o, respectively.

5. Proceed next to observe the same phenomenon with the new sample, for which Q is constant but unknown. It will be sufficient to confine the experimental variation of x to that vicinity for which the resulting value of y is found by trial to be of the same order of magnitude as y_o.

6. Plot the observed data on coördinate paper with y/y_o as ordinate against x/x_o as abscissa. Let the abscissa of point P where the experimental curve crosses the line $y/y_o = 1$, be denoted by x_1/x_o. This point represents a fictitious case of dynamical (or physical) similarity,

[3] E. BUCKINGHAM, THIS JOURNAL **4**: 347–353. 1914. Phys. Rev. **4**: 345–376. 1914. Trans. Am. Soc. Mech. Eng. **37**: 263–296. 1915.

[4] E. BUCKINGHAM. *Notes on the method of dimensions.* Phil. Mag. **42**: 696–719, § 11. 1921.

obtained by interpolation[5] between adjacent points at which the conditions for similarity were not exactly fulfilled. All of the inferences appropriate to physically similar systems are immediately applicable to the coördinates of the point P.

7. In particular, when $y/y_0 = 1$, Equation 14 leads at once to the final working formula

$$\frac{Q}{Q_0} = \frac{x_1}{x_0} \tag{15}$$

for determining the relative value of any property of matter Q. This formula is theoretically exact under the conditions stated, regardless of the complexity of the fluid motions, heat transfer, or electrical distributions involved in any given experiment.

GEOLOGY.—*The major tectonic features of the Dutch East Indies.*[1] H. A. BROUWER, Delft, Holland.

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INTRODUCTION

Although the geology of parts of the East Indian Archipelago was studied in detail during the past century by several geologists, a great many of the islands, particularly those in the eastern part of the Archipelago remained almost unknown geologically. But within the last twenty years so much new information has been obtained by expeditions to the more eastern islands that it is now possible to summarize the tectonic features of the entire region—one of unusual interest to geologists and geophysicists. Here two great lines of crustal weakness, the Alpine and the circum-Pacific orogenic systems, meet or are interlaced. Although it is convenient to speak of two stages of deformation in the East Indies, it is our opinion that the latest

[5] Instead of interpolating graphically, cases might arise where it would be of advantage to employ the relation connecting derivatives; cf. THIS JOURNAL 6: 620–629. 1916; or Bur. Stds. Sci. Paper 331. 1920.

[1] Address delivered before Geological Society of Washington. Feb. 2, 1922.

crustal movements in the East Indian region are only a younger stage and a direct continuation of the Tertiary crustal movements. The Tertiary folds and overthrusts which were formed at relatively great depth are now visible at the surface, but the fissured and faulted crust that once lay above them has been removed by erosion. On the other hand, the tectonic features due to late deformation near the earth's surface during the younger stage of mountain-building have remained visible and are manifested in the fissured and faulted crust, while the accompanying folds and overthrusts remain invisible at greater depths. Thus, we believe that the displacements, evidence of which is now seen at the surface, are in part the result of the continuation of movement at greater depths and that the visible traces of the different stages of crustal movement since Tertiary time are mutually complementary. A comparison of these stages affords a better understanding of the mountain-building process.

The evolution of the region during Paleozoic and Mesozoic time is not well known, but the widespread occurrence of Mesozoic deposits, which resemble in nearly every lithologic respect the recent deep-sea oozes, proves that already in Mesozoic time deep-sea basins were present in the region. Thus certain red clay shales with radiolaria and radiolarian hornstones are the lithologic equivalents of the Recent red clay and radiolarian ooze formed in deep seas of the present day. The hornstones in places contain nodules of manganese, some of which have a concentric structure, and teeth of sharks have been discovered in places. These deposits prove that very important movements of the earth's crust must have taken place since Mesozoic time; movements sufficiently great to bring deposits formed at depths of 5,000 meters or more to heights of more than 1,000 meters above the surface of the sea.

It is permissible to conclude that the process of mountain-building in the East Indian Archipelago bears much resemblance to that of other Alpine mountain ranges, such as the Himalayas and the Alps. In the Mediterranean region of Europe it has been possible to reconstruct theoretically different Mesozoic geanticlines and geosynclines, with the aid of stratigraphic data, when it was once realized that great over-thrust sheets had been pushed forward long distances from their original sites. The study of the Recent crustal movements in the rows of islands of eastern Asia and Oceania suggests what may have been the embryonic stage of Alpine mountain ranges when (in earlier periods) a somewhat similar distribution of land and water prevailed.[3]

[3] E. ARGAND. *Sur l'arc des Alpes occidentales.* Eclog. Geol. Helv. 14:145. 1916.

In the Western Alps we find that the formation of the geosynclines and geanticlines was accentuated in the Lower Jura; in Middle Jurassic time these folds disappear below sea level; and in the Upper Jura there followed a further moderate submergence. In Cretaceous time, strong horizontal movements began and reached their maximum in the Tertiary period. As the overthrust sheets moved at greater depth, the sea-basins became narrower and the masses of the geanticlines were pushed forward in a nearly horizontal direction.

Oscillations, such as these in the Alps during the Mesozoic period are also known to characterize the younger movements in the East Indian Archipelago, and it is possible that the region adjoining the present Australian continent will in the future reach the same stage as that reached long ago in the Alps. Horizontal movements of the curving rows of islands are proved by several features now observable on those islands and as these movements proceed the sea-basins will be narrowed and eventually the masses of the present geanticlines may be pushed over the Sahul shelf of the Australian continent. Viewed thus the Archipelago may be conceived as representing an embryonic stage of an Alpine mountain range. In zoology many of the results obtained through a study of comparative anatomy were later confirmed by the results derived from studies of embryology. The development of geology, however, naturally followed lines other than those of zoology because the embryonic mountain ranges lay outside the regions studied by early geologists, but it was possible deductively to reach conclusions regarding the embryonic conditions of a mountain range by studying the anatomy of a mountain range and by applying the ontological method, a method which much more than the comparative one, has controlled geological work.

It is probable that the embryonic stages of different mountain ranges bear much resemblance to each other, as do the early stages of animal ontogeny. Such a conception leads to the recognition of unexpected relationships between types, which because of mature age show important differences. The question arises, whether persistent embryonic types occur among the mountain ranges. In the Timor row of islands deep sea-basins occurred in Triassic time, while they appear in the embryonic Alps in the Upper Jura. It is possible that in the southeastern part of the Malay Archipelago a more or less embryonic stage has persisted since Mesozoic times, while the Alps reached the mature stage in Tertiary time. In my opinion the solution of many tectonic problems will be found by a careful study of compara-

tive tectonics, embryotectonics, and comparative embryotectonics, as in zoology comparative anatomy and ontogeny are essential parts of morphology.

The tectonic features of the East Indian Archipelago as they now exist are the result of orogenic forces which have been acting during long periods of time and which have caused movements in a horizontal direction at many places. Where the lands were high above the strand-lines of the surrounding seas, the ranges were cut down and the deeper parts were uncovered by erosion; *where at the same time the crust was moving below sea-level no denudation took place* and no unconformities or disconformities in the succession of strata are found. In the parts of the earth's crust, which are now visible on the different islands the erosion intervals are not found at the same place in the geological time-table. In Sumatra a striking unconformity is found between the late Mesozoic and the early Tertiary, in Timor between the middle Tertiary and the Plio-Pleistocene. In order to give a detailed account of the tectonic features it would be necessary to describe the many islands separately but for the major tectonic features it is sufficient to describe the visible traces of two stages of crustal movements, the late Mesozoic and Tertiary stage and the youngest stage, which still continues. *The youngest stage is definitely known to be limited to certain parts of the present Archipelago,* while the distribution in time and place of the older stage is not exactly known.

THE OLDER TREND LINES STUDIED IN PLAN

Digitate forms, such as those represented by the islands Celebes and Halmaheira have been considered as produced by a broad *side- and end-on* conflict of Tertiary folded ranges. See Fig. 1. Yet it can be shown that the present morphology is the result of the youngest stage of crustal movements, since the known strike of the Tertiary folds is in places very different from the direction of the present geanticlines. In the eastern peninsula of Celebes a northwest-southeast or north northwest-south-southeast strike is found in strongly folded marls and limestones with associated layers and nodules of hornstone. In the eastern part of this peninsula the central range consists of nearly horizontal limestones of Eocene and Oligocene age. On the northern and southern slopes more or less pronounced dips to the northwest have been found. In the central part of the island the main Tertiary strike seems to be northwest-southeast. The tectonic features of the southeastern peninsula of Celebes are but little known, its northern part

Fig. 1. Major tectonic features of the Dutch East Indies

consists principally of basic eruptive rocks and in the southern part crystalline schists, whose main strike is insufficiently known, are of widespread occurrence. In the narrow portion of the island, which connects the northern peninsula with the central part, some authors have presumed that there exists a main strike from south to north, which would bend to an east-westerly direction in the northern peninsula. But the region consists principally of crystalline schists and eruptive rocks and no folded Tertiary rocks are known, while a northwest-southeast strike seems to prevail. It is possible that the prolongation of the parallel ranges in the adjacent projecting part of Borneo crosses this part of Celebes obliquely and that the supposed bending of the Tertiary strike does not exist. Thus viewed, the Tertiary mountain-plan of the island may be thought of as comprising two strongly diverging trend lines of which the northern recurves to the north in the direction of one of the trend lines of the Philippine islands. To repeat, particularly in that part of the Archipelago which is occupied by the Island of Celebes there are *important differences between the Tertiary strike and the direction of the present geanticlinal axes.*

The geologic plan of Borneo in many respects resembles that of Celebes in that it is not well explained by a "side and end-on" conflict of folded ranges, but on the contrary suggests the existence of a system of branching trend lines similar to that of the present Philippine islands. From the northeastern part, where the highest elevations of the island occur and where the folded ranges with a main trend north-northeast to south-southwest are closely crowded together, the main strikes diverge to the southwest. The eastern trend lines bend to the southwest in the direction of Celebes, those more to the west first have a direction from north to south, but bend to the southwest, while the central and western ranges recurve to the northwest, almost at right angles to their general course in the northeastern part of the island.

The plan of Sumatra is similar to that of Borneo, although the branching of the trend lines is not so distinctly pronounced. The highest altitudes of the older rocks occur in the northwestern part of the island and the main trend lines diverge to the southeast.

The reconstruction of the main older trend lines in the eastern part of the Archipelago cannot be made complete, because that part of the region is mostly covered by the sea and older folds in many places are cut off by the present coast lines. There are, however, some indications that virgations also occur here. In the islands of the Kei

group a NNE-SSW strike is found on Great Kei, while farther west a NNW-SSE strike in the direction of Ceram has been observed. The strike on Great Kei is in the direction of western New Guinea, where the strike is parallel to the coast line (NNW and NW).

As far as known the main strike in different parts of Halmaheira Island does not greatly differ from the longer axes of the present peninsulas. But as the island has been crossed at only a few places and as eruptive rocks are of widespread occurrence, positive opinions on the tectonic relations are not warranted.

THE OLDER OVERTHRUSTS STUDIED IN PROFILE

The great deformation that took place during late Mesozoic and Tertiary time, and now so well exhibited on many of the islands was caused by strong pressure exerted from several different directions and the structures that were developed show the imbrication and the different degrees of overthrusting characteristic of Alpine mountain ranges. This structural type is probably of widespread occurrence, since it has already been proved or rendered highly probable that it is present on Sumatra and on many islands of the Timor-Ceram range. It has been suggested that the highest and the lower eastern parts of the Barissan mountains in Djambi (Sumatra) are parts of an overthrust sheet, between which the autochthonous phyllitic slates have been uncovered by erosion. An erosion relict has been found in the Bukit Raja.

In the Highlands of Padang the walls of Carboniferous or Permian limestone in places continue uninterruptedly without any transgression-conglomerates and without veins of granite or contact phenomena over the contact between granites and surrounding sediments, whereas part of the granites is post-Carboniferous in age. These limestones give to the landscape a peculiar character similar to that of the "Klippen" of the Alps and the Carpathian mountains and the "fatus"[3] of Timor.

On Timor the majority of the isolated rock peaks consist of coral reefs of Upper Triassic age, but Permian crinoidal and fusulina lime stones are common. Groups of deposits of the same age, but of different paleontological, and petrographical character, occur one on top of the other and "fatus" of older rocks are found resting on younger oceanic deposits, as is clearly visible along the deep ravines cut in the recently elevated island. The structure is as a rule chaotic and is similar to that of the higher overthrust sheets of eastern Switzerland,

[3] Isolated rocks or groups of rocks in Timor are called "fatu" by the natives.

which were moved in the near-surface zone where the rocks yielded to pressure not by flow but mostly by fracture. The comparative method of study leads to the supposition that on Timor the deeper complicated, but less chaotic overthrust structures, such as are found in the Western Alps, have not here been uncovered by erosion, and the absence of rocks older than those of Permian age points to the same conclusion. Simpler structures are found only in the southern coast-range of the island, where an imbricated structure with a fairly uniform dip to the north-northwest prevails. On Babber, an island to the east of Timor, crinoidal limestone has been found as isolated "fatus," which rest on folded Jurassic sediments. In the eastern part of Ceram Triassic sediments are thrust over limestones and marls, which are partly of late Mesozoic age and which show a rather regular dip to the southwest. In the central and western part of the island several remarkable successions of crystalline schists, phyllitic slates, and Mesozoic rocks point to the existence of important overthrusts between these three formations. In the western part of the island the horizontal movement of the overthrust seems to be less than that on the southern islands of the Timor-Ceram row, because groups of deposits of the same age, but of different paleontological and petrographical character, are not found one on top of the other and in close proximity in the same degrees as on Timor.

The expeditions from the south coast to the Snow Mountains of the central range of New Guinea found strata with a fairly uniform dip to the north over long distances and it does not seem improbable, that recumbent folds, imbricated structures, or overthrusts, with a movement in the direction of the Australian continent may occur in these mountains. This chain bears towards the lowland to the south and to Australia beyond a relation somewhat similar to that borne by the Himalayas towards India.

REGIONS WITH SIMPLER STRUCTURES

In Sumatra the overthrusts are older than Tertiary, in Timor they were formed in Miocene time. The Tertiary rocks of Sumatra up to the Pliocene generally have been folded, often in more or less regular broad anticlines and synclines, such as those of the oil-bearing strata in the eastern part of the island. Similar relations prevail in other regions where in Neogene time there were geosynclinal belts persistently and fairly well filled with an accumulation of sediments, as in parts of Java and Borneo and also on some islands in the eastern part of

the Archipelago. In some parts of the Archipelago the *Mesozoic and Tertiary rocks both show simpler structures.* In western New Guinea to the south of the Gulf of the Mac Cluer normally folded Tertiary rocks occur, and farther west, in the Misol-Obi-Sula row of islands in places the Jurassic strata are but slightly folded or are nearly horizontal. On Borneo crustal deformation of the late Mesozoic stage is clearly visible, but at many places the dip of the Cretaceous strata is not very pronounced. The tectonic structure may be more complicated in the northeastern part of the island, where the folded ranges are closely crowded together. Sumba, is usually considered as the western prolongation of the Timor row of islands, but the Tertiary is not distinctly folded.

On Celebes the ages of the different strata are not yet exactly known. It has been supposed that even Tertiary sediments occur amongst the metamorphic sediments, which are of widespread occurrence on the island, but as yet there is no proof of this supposition. In the central part of the island large anticlines and synclines with an approximately northwest-southeast strike were formed in post Eocene time. In the eastern peninsula nearly horizontal Eocene limestones occur, but at other places, as in the western part of the eastern peninsula, rocks of the same age are intensely folded. Although simpler structures with large anticlines and synclines certainly prevail in a large part of the island, we cannot gain an adequate picture of the late Mesozoic and Tertiary tectonic features of the whole island until the stratigraphy is more completely known.

THE MAIN TREND LINES OF THE YOUNGEST STAGE OF MOUNTAIN-BUILDING

The main trend lines of the latest stage of mountain-making are accurately known, because uplifts of the land relatively to the sea level are clearly demonstrated by the presence of elevated fringing reefs and because the positions of the deep-sea basins are given on the deep-sea chart of the "Siboga" expedition. The deep-sea basins have proved to be elongated more or less precisely parallel to the adjoining rows of islands and the main trend lines of the youngest stage of mountain-building nearly coincide with the longer axes of the islands. The deep sea basins and the strongly elevated islands are confined to the eastern part of the Archipelago, whereas within the western area there prevails a slight and uniform depth of the sea with smooth outlines of a land that rises with a gentle slope from the coast. Only the southern part of the Archipelago which is bounded by the Indian Ocean, shows

proof of recent upheaval of the land, while the deep-sea chart shows a complicated topography to the south of Java and Sumatra. That these movements still continue is proved by the distribution of earthquakes in the Archipelago. In the region including eastern Sumatra, the southern China Sea, northern Java, and Borneo, heavy tectonic earthquakes are practically absent. The shocks felt in this area have their origin in the mobile areas, which are as a rule submarine, as shown by the seismic epicenters.

The large bendings in the mountain chains of recent age in the southern and eastern parts of the Archipelago are clearly visible on the deep sea chart of the region. But if considered in detail it is obvious *that important bendings of smaller amount are numerous*. They are not always clearly visible in the present topography, because many of the bending-points, which are the loci of considerable transverse fractures, are covered by the sea. Examples of this kind are the narrow Manipa Strait between Ceram and Buru, nearly 5,000 M. deep, the strait between Timor and Rotti, the strait between Timor and the Sermata islands, and Sunda Strait between Java and Sumatra. In the row of islands from Nias to Enggano, to the west of Sumatra, several examples of this kind also occur.

TERTIARY STRIKES ARE CUT OBLIQUELY BY THE PRESENT GEANTICLINAL AXES

The establishment of the fact that Tertiary strikes are cut obliquely by the present geanticlinal axes is of great importance for a precise understanding of the mountain-building process. Several examples are known in the Dutch East Indies. On the south coast of Timor the strike of the Jurassic and Cretaceous strata of the Amanuban mountain chain differs about 12° from the general trend of the coast line. The high mountain range of central Ceram, in which the Mesozoic and Tertiary strata strike about NW-SE, is cut off abruptly at the coast with a general E-W trend. The abnormal strike in the eastern peninsula of Celebes and in the narrow portion which connects the central part of the island with the northeastern peninsula have been already mentioned. Another noteworthy example is on the island Babber to the east of Timor, where the strike is NNE-SSW, nearly perpendicular to the main trend of the present row of islands.

Similar facts are well known from Japan. Von Richthofen believed the formation of the arcs to be due to a rupture (Zerrung) caused by the subsidence of the oceanic side, and denied the existence

of the zonal structure that characterizes folded mountains of the Alpine type. Japanese geologists have already pointed out that many of the dislocations are only recurrent movements on the arcs of folding, which are of essentially the same type as the Himalayas and the Alps in their fundamental structure.

The abnormal strike can be explained in a simple manner by the action of compressional stress, if we suppose that the rows of uplifted and fragmented island blocks indicate the places where at greater depths folding continues and that there is motion in a vertical direction as well as *considerable motion in a horizontal direction*. The vertical movement will cause gradual erosion and the exposed surface of the geanticline will in time consist of rocks which were in the zone of flow during an earlier stage of mountain-building. The rate and direction of the movement of the deeper-lying rocks as they approach the earth's surface may differ more and more from the rate and direction of the motion of the rocks that lie at still greater depths on the same vertical line. The forces that cause movement near the surface will generally differ in intensity and direction from the forces that cause movement at greater depths. Furthermore, the rate of transmission of the forces will decrease from the surface to the zones of greater plasticity at greater depth. If during the elevation the rate of horizontal movement is different for neighboring parts of the geanticline, the differences between the directions of the geanticlinal axes and of the older strike may be considerable, as in the central part of Ceram. The strong bending of the geanticlinal axis between Ceram and Buru points to important differences in the rate of horizontal movement for neighboring parts of the geanticlines. A bending-point existed in this region already in Tertiary time and near strong bendings, as near Babber Island, the Tertiary strike may locally even be at right angles to the present geanticlinal axis. It is particularly in such places that the movement at or near the surface may differ considerably in rate and direction from the movement of greater depths.

THE FRACTURES DURING THE YOUNGEST STAGE OF MOUNTAIN-BUILDING

The tension hypothesis of von Richthofen has been applied by some authors to the East Indian Archipelago, but the numerous fractures, which are known to exist, are in our opinion the surface expression of vertical and horizontal movements which are the result of compressional stress. Important fractures occur near the surface at those places where there are important differences in rate of move-

ment. If the forces which cause the movement are deep-seated and if the crust near the surface does not respond to the direct influence of the compressional stress, displacements near the surface will result from the more plastic deformation at greater depth. While important horizontal movements are taking place in the zone of plastic deformation, the superficial parts may move with much less velocity.

If the superficial parts are bent, whether in a vertical or horizontal plane, there is a tendency to produce gaping fissures upon the convex side of the bend, while there is compression upon the concave side. Some of the fissures in the Archipelago may be of this origin, and many have been explained in this way, such as the basins of central Celebes, which are arranged in straight lines, more or less parallel to the geanticlinal axes. If studied in plan, the same principles are applicable and perhaps some of the straits between the islands of an arc have been formed in this way. Considerable transverse fractures, however, which occur at many places near the bending-points of the geanticlinal axis, can be explained by *difference in velocity of horizontal movement* for neighboring parts of the fold along the axis. In the same way important longitudinal fissures can be explained by the difference in velocity of neighboring parts of the geanticline considered in a vertical plane at right angles to the geanticlinal axis. The morphological aspect of the surface will be controlled chiefly by the more or less horizontal movements on transverse fault planes, the gaping transverse fissures on these planes the more or less vertical movement on longitudinal faults, and the gaping longitudinal fissures on these faults. The movements along more or less horizontal fault-planes will not be of much importance for the major morphological structure and will receive no further consideration.

Typical examples of transverse fractures near the bending-points of a geanticlinal axis where it has moved forward horizontally are Sunda Strait between Java and Sumatra, the strait between Timor and Rotti, and the narrow strait between the main island of Rotti and the peninsula of Landu. To the east of Timor the small Island of Kisser which is surrounded by deep seas and is in the neighborhood of a bending point between east Timor and the Sermata Islands occupies a northern, non-harmonic position. Farther to the east the Babber group, which consists of small islands with high reefs, is separated by a considerable gap from the islands of the Tenimber group. The narrow strait between Muna and Buton and the straits between other

islands of the same group are near the bending-point of the geanticlinal axis of the Tukang Besi Islands and southeastern Celebes. The narrow Manipa Strait, nearly 5,000 meters deep between Ceram and Buru is another example of an important gap where there is strong bending of the geanticlinal axis in a horizontal plane, while the strait between Halmaheira and Morotai and the important gap between Halmaheira and the islands to the southwest of the Pelew group may in part be the result of fractures near a bending-point, which possibly exist between Halmaheira and those islands. Of course in large bendings of the geanticlinal axis the submarine parts of the axis may be due to a pitch of the axis, but for relatively short bendings this explanation of submarine portions alone is not applicable. The fracture-movement may be more or less parallel to a fault-plane or the movement may have an important component normal to the fracture-plane The bending-points of the surface of the geanticline, considered in a vertical cross section of the geanticline at right angles to the geanticlinal axis, are between the deep sea-basins and the elevated islands, where longitudinal faults may cut away the land at the coast as has been mentioned for many islands of the Archipelago. If two more or less parallel rows of islands are developing as two secondary geanticlines with an intermediate secondary geosyncline, longitudinal faults may exist on both sides of the secondary geosyncline and on the outer sides of the secondary geanticlines. The duration, speed, and place of the fracture-movements will in large measure depend upon the evolution of the mountain-building. If the plane of movement is not constant and the traces of older fracture-movements are elevated above the sea, they will usually disappear rapidly through erosion on the outer side of the geanticline. If the secondary geosyncline during its slow subsidence constantly remained fairly well filled with an accumulation of sediments and if in a later stage of evolution a general elevation of the secondary geosyncline and geanticlines takes place, the filling of the central basin will serve as evidence of older fracture-movements on both sides of the original secondary geosyncline. Different stages in this evolution are represented in the Timor-Ceram row of islands.[4] The islands of the Tenimber group consist of two rows with elevated reefs, which are separated by a zone in which during the latest stage of the mountain-building process positive movements have prevailed. At Timor the geanticline may have already passed through the stage of

[4] H. A. BROUWER. The horizontal movement of geanticlines and the fractures near their surface. Journ. of Geol. **29**: 566. 1921.

development represented by Tenimber Islands. Flexures and faults of considerable horizontal magnitude occur at the walls of a central basin which has been formed and filled with sediments in Plio-Pleistocene time. Later a general elevation of the island has produced the large anticline of the present island, with the highest reefs in the central part. We suppose that in this later stage of evolution the rate of horizontal forward progression of the deeper parts was greater than that of the superficial parts and that the parts which were near the surface and originally were above the downward moving secondary geosyncline were in a following stage of evolution above rising parts at greater depth and were, therefore, elevated above the sea.

A fine example of parallel rows of islands which are developing as geanticlines with intermediate geosynclines are the Tukang Besi Islands southeast of Celebes. They consist of four rows—two of which bear elevated reefs and mark the geanticlinal axes; while the other two are characterized by reefs and atolls, and mark the geosynclinal axes.

Only a limited number of the general types of fracture-movements have been described. The position of the fissures and faults is controlled by a great many factors, the discussion of which would exceed the scope of this paper. But the types mentioned sufficiently illustrate the thesis, that the majority of the fractures in the East-Indian Archipelago are the surface expression of differences in velocity of horizontal and vertical movements, which are the result of compressional stress. That these movements still continue is proved by the position of the epicenters of modern earthquakes, of which we will mention those along the southwestern prolongation of the transverse dislocation in Sunda Strait between Java and Sumatra.

LITERATURE AND MAPS

A bibliography of the more important publications on this subject to 1917 is given in the Jaarboek van het Mijnwezen in Ned. Indie, Verhand. 1917, II, with Atlas. Our map is compiled from the maps in this atlas with additional information.

Since 1917 there have appeared other publications for which see the annual bibliography of geological publications on the Dutch East Indies by R. D. M. VERBEEK in Verhand. Geolog.—Mijnbouwk. Genootschap voor Nederland en Kolonien.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

858TH MEETING

The 858th meeting of the Philosophical Society of Washington was held in the Cosmos Club auditorium, December 17, 1921 and was called to order at 8.15 p.m. by President CRITTENDEN, with thirty-nine persons present. The program was as follows:

W. W. COBLENTZ: *The effective temperature of stars as estimated from the energy distribution in the complete spectrum* (illustrated). The paper was discussed by Messrs. PRIEST, HAWKSWORTH, FOOTE, HUMPHREYS and CRITTENDEN.

The object of the present investigation was: (1) to test new stellar thermocouples; (2) to verify previous measurements of stellar radiation; (3) to measure the radiation intensities of bright stars in the region of 0 hours to 12 hours of right ascension, not previously measured; and (4) to determine the feasibility of the method of obtaining the spectral energy distribution of stars by means of transmission screens which, either singly or in combination, are placed in front of the vacuum thermocouple.

By means of vacuum thermocouples, measurements were made on the total radiation intensities of 13 bright stars not observed in 1914, thus completing the survey of the whole sky. A total of 30 celestial objects were measured, including Venus and Mars.

By means of a series of transmission screens (of yellow and red glass, of water, and of a thick plate of quartz), wide spectral regions were isolated and the radiation intensities in the spectrum from 0.3μ to 0.43μ; 0.43μ to 0.6μ; 0.6μ to 1.4μ; 1.4μ to 4.1μ; and 4.1μ to 10μ were determined. In this manner the distribution in energy in the spectra of 16 stars was determined, thus obtaining for the first time an insight into the radiation intensities in the complete spectrum of a star.

By means of these transmission screens it was found that in the B and A-class stars, the maximum radiation intensity lies in the ultra-violet (0.3μ to 0.4μ) while in the cooler, K and M-class stars, the maximum emission lies at 0.7μ to 0.9μ, in the infra-red.

A calculation is made of the spectral component radiations of a black body at various temperatures, using the spectral transmission data on these screens. From a comparison of the observed and the calculated spectral rediation components, it appears that the black-body temperature (*i. e.*, the temperature which a black body would have to attain in order to emit a similar relative spectral energy distribution) varies from 3,000° C. for red, class M stars (6,000° for the yellow, solar type) to 10,000° or perhaps even higher for blue, class B stars.

The observing station being much higher than that previously used (7,300 feet as compared with 4,000 feet), the atmospheric scattering of light was greatly reduced; consequently, when the water cell was interposed the transmissions in the violet were somewhat higher than previously observed. However, all the data verify previous measurements showing that red stars emit 3 to 4 times as much infra-red radiation as blue stars of the same visual magnitude. Moreover, observations made on the same night (same weather conditions) are consistent in showing small gradations in the infra-red radia-

tion component that correspond with the small gradations (say B2 and B8) in spectral classes.

For binary stars having companions of low luminosity the water-cell transmissions are low, indicating that the companion stars emit considerable infra-red radiation.

Among the subsidiary investigations made with a view to the improvement of stellar radiometers, the complete paper gives data on the radiation sensitivity of thermocouples of alloys of gold-palladium, platinum-rhodium, bismuth-tin, bismuth-antimony, and also of pure bismuth.

In conclusion, it is relevant to note that in comparison with the photoelectric cell the thermocouple is far less sensitive, and hence the number of stars that can be measured by it is more limited. Neither instrument can tell us the size or distance of stars. The thermocouple enables one to obtain information not obtainable by other instruments. Combined with an absorption cell (of water) one can detect the presence of dark companions of binary stars. This device also gives us a new means for studying planetary radiation and temperature conditions. If the surface of a planet becomes warmed by the sun's rays, and in turn emits radiation (which will be entirely of long wave-lengths) the amount of radiation transmitted through the water cell will be less than when the reflecting surface remains cool. Data of this type were previously obtained on the moon. Applied to the planet Mars, if the polar cap is snow, then the transmission of reflected sunlight should be higher than that observed from the dark areas, if the latter are bare ground. On the other hand, if the dark areas contain green vegetation (similar to that of our earth) the temperature rise will be small, the water-cell transmission will be high, and the results may be difficult of interpretation.

PAUL D. FOOTE, F. L. MOHLER and W. F. MEGGERS: "*A significant exception to the principle of selection*" (presented by Mr. Foote and illustrated). The paper was discussed by Mr. HAWKSWORTH.

The pair 1s—3d of sodium and potassium, in Sommerfeld's theory necessitates an interorbital transition where the change in azimuthal quantum number is two units. The presence of this pair has always been attributed to the incipient Stark effect of the exciting field. In the present paper an experimental arrangement is described wherein the radiation is completely shielded from the applied field, itself only 7 volts. The pair may then be produced at will by increasing the exciting current until it is one of the strongest lines of the spectrum. It therefore is an exception to the selection principle which cannot be explained away by a Stark effect. Its explanation is of deeper origin, possibly requiring a reconsideration of the method whereby single azimuthal quantum numbers have been assigned to each of the s, p, d and b terms.

WALTER P. WHITE: *Some precision pendulums* (illustrated). The paper was discussed by Messrs. PAWLING, PRESS, TUCKERMAN and SILSBEE.

Pendulums are practically always driven by a push in the direction of motion. This may take two forms: (1) A direct push is given symmetrically about the middle of the stroke. This is usually done by force applied at right angles to the direction of motion, acting on an inclined surface (pallet). This method involves considerable friction and consequent possibility of irregularity. (2) The pendulum meets and pushes against a pallet which acts on an opposing weight or spring, and which follows the pendulum in the return to a point beyond that at which it was picked up. The opposing pallet

is then brought back to the original position by the driving train of wheels. This arrangement is equivalent to a push over the distance between the two points, those of meeting and leaving the pallet. Here friction is less, but is not completely absent, since there is friction in unlocking the train each time it moves.

If electric working is introduced friction can be entirely avoided. An impulse can be given magnetically at the middle point of the swing, but the difficulty of keeping this impulse constant and applying it at exactly the right time seems to make this method less satisfactory than an electrically-operated form of the second type of drive, which is now exceedingly simple. The pendulum merely lifts a small pallet, contact with which causes a current to flow, which by means of a magnet shifts the stop of the pallet. Contrary to some rather positive statements, it has been found by several experimenters that the contact in this form of drive can be operated without any friction and with pressures less than 1 gram.

Some very simple equations were developed for determining the magnitude of the errors with this arrangement, and hence the best practical dimensions to give it in any particular case. These equations are applicable to the other forms of drive, and show: (1) A light and long pallet is preferable as long as the pressure is sufficient for proper contact. This is because the errors due to friction, or to displacement, or wear of the stops, become less as the length increases. (2) The error from displacement of the stops, that is, from improper timing of the driving pressure, is a minimum when this pressure extends over half the swing. Contrary to much received opinion, therefore, an instantaneous impulse at the middle of the swing may be a relatively disadvantageous method of driving. (3) It is possible, and sometimes probably advantageous, with the second form of drive, to arrange to compensate for the circular error of the pendulum, that is, the error caused by variation in arc of swing. (4) In the Riefler mechanism, which belongs to the second type of drive, the driving pressure acts over an arc which is dependent on the speed with which the escapement wheel revolves when unlocked. This is really a disadvantageous element in the design, against which, however, are to be set the efficiency of the unlocking arrangement and the general good workmanship of this make of pendulum.

Adjournment at 10 p.m. was followed by a social hour.

H. H. KIMBALL, *Recording Secretary.*

BIOLOGICAL SOCIETY

627TH MEETING

The 627th meeting of the Biological Society of Washington was held in the lecture hall of the Cosmos Club, May 14, 1921, at 8.00 o'clock. President HOLLISTER was in the chair, and 28 persons were present. The minutes for the 626th meeting of April 30 were read and approved, and the following were elected to membership: DR. RUDOLPH KURAZ, MR. E. C. LEONARD and ROBERT F. GRIGGS. It was announced that the present meeting was the last before the summer recess.

Informal Communications: Dr. T. S. Palmer stated that doubt rests upon the native origin of oppossums in California. There is a record ninety years old of oppossums on the California-Mexico border. Dr. Grinnell shows, however, that oppossums were introduced in the San Jose neighborhood in

1910, and these have flourished. 200 skins have been marketed in the last two years. Dr. R. W. Shufeldt exhibited two new books, (1) Early Annals of Ornithology, by John H. Gurney, containing quotations from early literature. (2) Life of Samuel White, by his son, Capt. S. A. White. Mr. F. C. Lincoln stated that one of a hundred common tern which were banded in Eastern Rock, Maine, on July 3, 1913, was found floating upon the Nile River, Africa, in August, 1917. This record points to the possible identity, which has been questioned, of the European and American Common Tern. Dr. R. E. Coker announced a 3 day conference to be held in June at Fairport, Iowa, on conservation of life in inland waters, under the chairmanship of Dr. S. A. Forbes. Great interest and appreciation of the problems involved is already apparent. Mr. Libbey stated that during the day Bicknell's Thrush had been seen, and Rose-breasted Grosbeaks were feeding upon oak galls. Dr. T. S. Palmer stated that while Bicknell's Thrush undoubtedly passes through the District of Columbia, it had never before been seen. It was described from Colombia many years before Bicknell was born. Dr. Palmer made a minute upon the death of Mr. William Palmer, born in England in August 1856, died in New York City, April 8, 1921. He was appointed taxidermist in the National Museum at the age of 18, where much of his work exists. He was on many extended tours, and was a member of the Council of the Society at the time of his decease.

Formal Communications: F. G. ASHBROOK, *Recent notes on the fur trade in the United States.* He said in part: Prior to the World War the world's fur market was in London. St. Louis and New York now are the fur centers. The value of the raw skins ranges from 1–7 millions annually. In 1920 the finished value was $84,000,000; exports were $34,000,000. The turnout during the 1920 fur sale in 1921 will be $352,000,000 in which the taxes will be $15,000,000. Thus the growth of a once neglected industry: Fur bearing animals are little protected by general agitation among the public. It requires legislation which preserves the game without destroying the trade. Since 25% of the skins are unprime, the seasons should be properly limited and trappers licensed. Reports should be made under oath, and licenses should be denied or cancelled upon occasion. Certain regions should at times be closed, with proper protection to farmers against enemies. The laxity of enforcement of laws in some states is to be deplored. Rearing and stocking is to be encouraged; it is successful when intelligently done. There are 500 persons in the United States breeding animals for their skins.

Mr. Ashbrook's paper was discussed by Mr. Doolittle and Dr. Palmer.

MR. S. A. ROHWER: *Injurious and beneficial insect galls.* He said: A gall is a malformation in plant tissue made in course of the development of insect larvae. Galls may be due to the irritation of oviposition or to some enzyme or both. In either case the insect has abundant nourishment. The galls made by different insects are characteristic. Galls have furnished topics for poems and other literature. Their use in medicine is based largely upon superstition, but they are a source of astringents.

As related to man some galls are slightly or not at all injurious to plants in which he is interested. Such are the Cynipid galls on oak leaves, and many others on roots and twigs. The beneficial aspect of galls is recent. They are the basis of some dyes, and all permanent black inks of United States and Europe. The superiority of London seal skins over Paris skins was due to the Aleppo gall from Turkey. A Chinese gall produced by aphids on *Rhus*

is a fair substitute for the Turkey product. One firm uses $150,000 worth in one year. The California Oak Apple is large, contains 30% tannic acid, and makes satisfactory ink. The Texas Ball also has high content.

There are two types of tannin, the iron-green and the iron-green-blue. The chemistry of galls still requires investigation, as not all galls produce tannin of equal value.

Some galls are injurious. In 1917 galls destroyed in a large area all the acorn catkins, destroying the acorns and the hog forage in that region. Other galls kill growing tissues, causing a second growth. An internal gall occurs in California. No damage is observable until the insect emerges and no defensive measures are possible.

The paper was illustrated by lantern slides of various galls and gall insects, and tables showing the tannin content of many fresh and cured galls. Mr. E. A. Goldman discussed the paper.

The Society adjourned at 9.55.

A. A. DOOLITTLE, *Recording Secretary.*

628TH MEETING

The 628th meeting of the Biological Society of Washington was held in the Lecture Hall of the Cosmos Club, October 29th, 1921, with Vice President GIDLEY presiding, and 36 persons present. The minutes of the 627th meeting of May 14th were read and approved, and Messrs. FRANK E. ASHBROOK and J. WADE were elected to membership, and Mrs. JULIUS PARMALEE and Miss ERMA BROWN.

Informal Communications: Dr. T. S. Palmer announced the annual meeting of the American Ornithological Union at Philadelphia on the 8th, 9th and 10th of November. Dr. H. M. Smith gave some records of the Kamchatka Sea Eagle. The bird had been seen at Urangel in 1905, at Unalaska in1906 by Austin Clark and by Professor J. V. Snyder, seen also in Juneau in 1909. Specimens have been taken by Dr. Hansen at the Pribloff Islands, and again a specimen was taken at Kodiak Lake August 10 of this year. This is not a marine bird, but rather of forests and rivers.

Formal Communications: DR. R. S. BASSLER: *Sex characters in fossils.* The speaker said that sex is recorded plainly in vertebrate skeletons, and thus easily recognized in fossils, but a similar condition does not occur generally among invertebrates. However among Bryozoa and Ostracoda found as fossils sex organs are present.

Recent Ostracods are without external sex structures, but paleo-species have little swellings which careful study proves to be brood pouches, thus distinguishing the sexes. The form, size and arrangement of these pouches assist in their classification. Silurian and Paleozoic species are found with these pouches, earlier and later species are without them.

The general structure of Bryozoa was described and the relation of the brood pouch or ovisac to the rest of the anatomy was shown. The transition from a very simple type to a more complicated type was traced, and the taxonomic value of this character was shown. It is only in the form or position of the brood pouches or ovisacs that distinction between many species is found. Many species formerly regarded as identical are now differentiated. All previous classification has thus been rendered obsolete; only those species are classified in which the distinctive character appears as shown in the ovicell.

The paper was illustrated by numerous lantern slides and was discussed by Messrs. Gidley, Rohwer, Oberholser and Doolittle.

DR. W. E. SAFFORD: *The Dahlia, its origin and development.* Dr. Safford stated that the botanical relationships of the cultivated Dahlia are difficult to trace, having been crossed and recrossed under cultivation before they were known to Europeans. They were first described and figured in 1791, from specimens of Mexican origin by Cavanilles. Descriptions of some Dahlias antedate the technical descriptions some 200 years in a study of the resources of New Spain. At that time Hernandez describes varieties in form and color showing that types thought to be modern were already developed. Many of the interesting and remarkable modern forms have been developed by crossing with a distinct type, *Dahlia juarezii*. Wild species have been found in the mountains of Mexico and Central America by Maxon and Popenoe which bear their discoverers' names.

The roots of the Dahlia are clustered and fleshy, containing not starch but inulin, from which levulose or fructose is obtained. Owing to a bitter flavor the roots are rejected by cattle and pigs. The levulose, however, is 60% sweeter than sugar, and, since it crystallizes with difficulty, has great possibilities as a syrup in sweetening drinks and desserts and preserves.

Dr. Safford's paper was illustrated with many beautiful colored slides of the various types of Dahlias, including reproductions of the earliest drawings. The paper will appear in another connection in the Journal of the Washington Academy of Sciences. The paper was discussed by Messrs. Rohwer, Oberholser and others.

The Society adjourned at 10.00.

A. A. DOOLITTLE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

The Executive Committee of the Institute for Research in Tropical America held its first meeting Saturday, January 14, at the rooms of the National Research Council, for the purpose of organizing. A. S. HITCHCOCK, representing the Smithsonian Institution, was elected Chairman; H. E. CRAMPTON, of the American Museum of Natural History, Vice-Chairman; and A. G. RUTHVEN, University of Michigan, Secretary-Treasurer. The Institute now includes 19 members.

Arrangements have been completed for enlarging the scope of the *Journal of the Optical Society of America*. Beginning January, 1922, the publication will be known as the *Journal of the Optical Society of America and Review of Scientific Instruments*. In addition to the papers on all branches of optics heretofore carried, about three eighths of the total space will be devoted to instruments other than optical. Beginning with May, 1922, the Journal will be issued monthly instead of bi-monthly. The new Journal has been placed on a strong financial basis and has the support of the Optical Society, of the Association of Scientific Apparatus Makers of the United States of America, of the National Research Council, and of several philanthropic individuals interested in making the plan a success. Authors will welcome this new feature as it affords almost the only source for the publication in this country of papers describing instruments. DR. PAUL D. FOOTE of the Bureau of Standards is editor-in-chief and DR. F. K. RICHTMYER, Cornell University, is assistant editor-in-chief and business manager.

Among recent accessions by the Division of Plants are the following:

692 specimens of West Indian plants, chiefly from Trinidad, received as an exchange from the New York Botanical Garden; 836 specimens from Brazil, collected many years ago by GARDNER and containing a large number of duplicates of types, received as an exchange from the British Museum; 593 Panama ferns presented by MRS. L. R. CORNMAN, San Diego, California; 400 specimens from the French Congo, received as an exchange from the Jardin Botanique de l'Etat, Brussels; 277 African grasses collected by DR. H. L. SHANTZ, received as a transfer from the Bureau of Plant Industry, U. S. Department of Agriculture; 300 Panama plants presented by Brother HERIBERTO, Panama City; 167 Cuban ferns, received as an exchange from the New York Botanical Garden, and 126 Philippine orchids, largely cotypes, received as an exchange from MR. OAKES AMES, Boston, Massachusetts.

A series of specimens showing the complete working of the "Manul" process of reprinting sent by the Polygraphic Company of Laupen-Berne, Switzerland, is on exhibition in the Division of Graphic Arts, Smithsonian Institution. This process eliminates all resetting of type or the use of a camera. The page is placed in contact with a sensitized transparent film and exposed to the light. The light reflecting from the white parts of the original affects the sensitized film while no reflection of light from the blacks leaves the film unaltered. This film is used as a negative after being treated with coloring matter and transfers the image to the zinc or aluminum plate which is printed on a lithographic press in the customary manner.

In this process any work, written, drawn or printed, can be reproduced at an obvious saving over older methods involving resetting all type matter or making photographic negatives by the use of a lens and camera. The exhibit includes the original pamphlet, the "Manul" film, the zinc lithographic plate and a finished print.

Dr. C. G. ABBOT, Assistant Secretary of the Smithsonian Institution, returned to Washington January 4 from a trip of inspection to the Institution's solar radiation station at Montezuma, near Calama, Chile.

Captain ROALD AMUNDSEN, the well-known polar explorer, visited the Department of Terrestrial Magnetism of the Carnegie Institution of Washington on January 16, in order to complete arrangements with regard to coöperative work in terrestrial magnetism and atmospheric electricity between the Department and his forthcoming expedition to the Arctic Regions. During the Northeast Passage, 1918–1921, the Amundsen Expedition made a series of highly valuable magnetic observations at somewhat over 50 different points. Captain Amundsen's chief scientific assistant, Dr. H. U. SVERDRUP, has been associated with the Department of Terrestrial Magnetism since last October in order to complete the reduction and publication of the magnetic observations thus far obtained by the Expedition. He will rejoin the *Maud*, Captain Amundsen's vessel, early in March at Seattle. It is expected that Captain Amundsen will resume his arctic expedition about June 1. During his brief stay in Washington, Captain Amundsen also paid a visit to the non-magnetic ship *Carnegie*. In the evening he met at the Cosmos Club a number of the scientific men of Washington with whom he discussed the plans of his arctic expedition, the chief object of which is to obtain scientific data relating to geography, oceanography, meteorology, gravity, terrestrial magnetism and atmospheric electricity.

AUGUST BUSCK has recently returned from an extended trip in the West

Indies, where he was investigating the pink boel worm of cotton for the Bureau of Entomology.

Mr. FULLER CLARKSON resigned from the Fixed Nitrogen Research Laboratory December 1, 1921, to accept a position in the research laboratories of the Procter and Gamble Company, Cincinnati, Ohio.

Dr. A. S. HITCHCOCK, of the Bureau of Plant Industry, returned on December 23 from a trip to the Orient where he went to study the grasses, especially the bamboos. He visited the Philippines, Japan, central and south China, including the island of Hainan, and Indo-China.

Representative ALBERT JOHNSON of Washington was appointed a regent of the Smithsonian Institution on January 4 by Speaker GILLETT of the House, and Representatives LEMMEL PADGETT and FRANK L. GREENE were reappointed as regents.

ADOLF TONDUZ, the well-known botanical collector in Central America, died at Guatemala City, Guatemala, in the latter part of 1921. Mr. Tonduz was a native of Switzerland, who received his early botanical training under Alphonse De Candolle, and emigrated to Costa Rica in early manhood. He was for many years connected with the Instituto Físico-Geográfico of San José, of which H. Pittier was director, and was associated with Mr. Pittier in a natural history survey of Costa Rica. His specimens are well represented in the U. S. National Herbarium and in the other large botanical establishments of the world.